Basic Carbonate White Leads

Their Properties and Use *in* Paint Products

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INTRODUCTION

This paper deals with Basic Lead Carbonate and has been written in an effort to submit specific information regarding its composition and its behavior as a paint pigment.

The general discussion on white lead is followed by data on the chemical and physical properties of the various types of basic lead carbonate at present manufactured and marketed by National Lead Company.

The wider applications of white lead are also discussed, the subject being treated both from a general point of view and in detail. Moreover, there is included a description of a simple and practical method for volumetric paint formulation which will be of interest to the manufacturer.

This paper also contains a number of useful charts giving weight-volume equivalents and other valuable information.

NATIONAL LEAD COMPANY

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WHITE LEAD

The most commonly used house paint is a mixture of pigment and linseed oil whose function it is to protect and beautify the surface on which it is applied. The value of a paint pigment in such a paint is determined by the service it is able to render as a paint constituent. And while both pigment and vehicle must possess certain essential properties to produce quality paint, the pigment phase undoubtedly contribues a major share.

The characteristics on which a house paint is judged or rated are listed below in the order in which they become apparent during the use and life of the paint. They are:

Keeping characteristics	Leveling	Durability
Brushing qualities	Rate of drying	Wearing
Hiding Power	Appearance	Adhesion

White lead, due to its unique chemical and physical make-up, contributes in a positive way to a greater number of these characteristics than does any other individual white pigment.

Keeping Qualities

The presence of white lead in the pigment phase of a paint will help to prevent hard settling. An important factor in this respect is white lead's affinity for paint vehicles, notably linseed oil. It wets easily and readily, resulting in a homogeneous combination. An example of this fact may be found in the process of manufacturing paste lead where water pulp is brought into contact with linseed oil which promptly displaces the water.

Brushing Qualities

It is common knowledge in the painting trade that white lead and linseed oil paint has excellent brushing qualities.

Hiding Power

An investigation of 45 well-known prepared exterior house paints disclosed that the hiding may vary from 129 to 355 square feet per gallon. By the same method used in making hiding tests on the exterior house paints, straight white lead paints showed a hiding power range of 195 to 300 square feet per gallon. More detailed data covering the hiding range of white lead will be given.

Leveling

It is an accepted fact that paint formulated with white lead and linseed oil will flow out better than one formulated with any other white pigment under the same conditions. Therefore, when mixed pigment paints are formulated, satisfactory leveling and flow will be more readily obtained as the percentage of white lead in the pigment mixture is increased.

Rate of Drying

Due to its composition, white lead contributes drying action to paint. Therefore, its inclusion in mixed pigment formulations minimizes the danger of loss of drying power which may occur through adsorption of drier on the surface of pigment particles. Often the proportion of drying agent required can be decreased with an increase in white lead content.

Appearance

Paint containing white lead tends to form smooth, even and uniform films. Also white lead is not subject to discoloration produced by washings from copper screens or the rusting of nail heads.

Durability

The durability which white lead gives to paint is due to its physical and chemical characteristics. It possesses the ability to form paint films of optimum toughness primarily due to a limited reaction with the oil vehicle at the surface of the white lead particles. For this reason a pure white lead film does not crack or scale. It likewise follows that the inclusion of a liberal percentage of white lead in a paint film will proportionately reduce the chances of this failure.

Wearing

As a result of the fact that white lead paint wears down by slow chalking it leaves a perfect surface for repainting. No scraping or burning is necessary to prepare the surface for the application of new paint coats. The preparation of a surface by burning and scraping may almost double the cost of a repaint job.

Adhesion

No matter how good a paint film may be, it becomes worthless when lack of adhesion causes it to leave the surface on which it has been applied. It is conceded that white lead contributes more to the adhesive properties of a paint than any other white pigment. No exterior primer of which good performance is expected can be produced without the aid of white lead.

The preceding clearly demonstrates that white lead furnishes a combination of properties essential to good paint. Further proof of this is the fact that white lead is the only white pigment which can be and is successfully used by itself to produce satisfactory exterior paint. Paint containing a large proportion of white lead will be less affected by manipulations on the part of the consumer than paints which do not contain this pigment.

The excellent record for white lead causes it to be generally recognized as the backbone of good paint. Its many adaptations to paint products have become so varied that special white leads having different paint-making properties have been developed to meet the demand.

AVAILABLE TYPES OF WHITE LEAD

In order to satisfy the increasing demand for white lead in paint products and to furnish a variety of properties for different requirements, a number of types of white lead have been developed.

At present National Lead Company is marketing five types of white lead, all basic lead carbonates. The processes selected for the production of these pigments are such that the fundamental characteristics, to which white lead owes its world-wide reputation, are retained.

Table A below gives some specific information regarding the National Lead Company white leads. The figures represent averages and are primarily meant to illustrate the comparative relationship among the different types. The variations in properties listed are clarified by the following comments.

TABLE A

NATIONAL LEAD COMPANY WHITE LEADS

	Dutch	*Carter*	*H.T.S.*	*333*	*111*
Composition (Percentage of $PbCO_3$)	69-72	66-69	64-67	64-66	62-64
Specific Gravity	6.7	6.7	6.7	6.8	6.8
Bulking Values (Lbs. per Solid Gallon)	56	56	56	57	57
(Gallons per Pound)	.0179	.0179	.0179	.0175	.0175
Color	1	00	00	00	00
Fineness (Portions retained on a No. 325 Sieve than—%)	.2	.1	.1	.1	.1
(Average diameter of particles by surface mean—microns)	2.3	1.8	1.5	1.2	.9
Tinting Strength	100	120	140	180	220
Hiding Power (Complete Hiding in Linseed Oil Paint over a Black Background—Sq. Ft. per lb.)	13	15	17	21	25
Oil Absorption (Pounds per 100 pounds)	8	9	10	14	15
Paint Consistency (71.3% Pigment—Seconds)	12	16	30	∞	∞
(62.0% Pigment—Seconds)	5	7	9	15	25
Paint Thickening Power (% Pigment in 20 Second Consistency Paint)	76	74	67	63	61
(Pounds of Pigment in One Gallon of 20 Second Consistency Paint)	17	16	12	11	10

Composition

Although the average composition of white lead has usually been considered to conform substantially to the formula $2PbCO_3.Pb(OH)_2$ containing 68.9% of $PbCO_3$, the different manufacturing processes will produce white leads which differ somewhat in chemical composition. The lead carbonate content may vary from the proportion in which it exists in the above theoretical formula with a resulting variation in basicity. This in turn brings about changes in the physical properties of the pigments. Careful control of the manufacturing methods keep the chemical and physical properties of the various white leads within limits.

Specific Gravity and Bulking Values

Because of the changes in composition slight variations in specific gravity must follow. With an increase in basicity a higher lead content will exist which slightly raises the gravity and correspondingly reduces the bulking.

Color

The color grading is made in linseed oil paste on a standard scale established by the National Lead Company in which: 1—Represents the color of the best type of Dutch process white lead; 00—Represents white lead of superior color.

Particle Size

The figures given for this property represent practical averages and illustrate the comparative fineness in terms of average diameter by surface mean. The photo-micrographs (magnification 1000X) on page 6 give an idea of the average relative particle size.

Tinting Strength

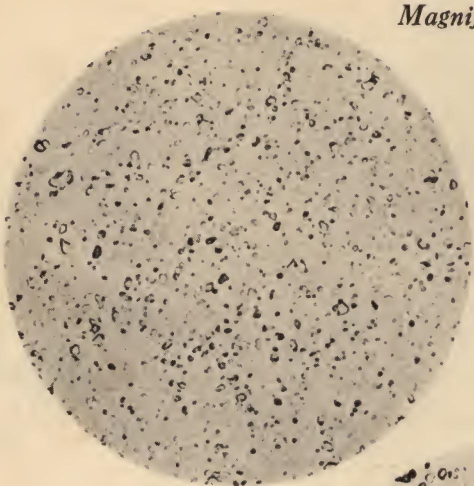
The tinting strength determinations are made with a linseed oil paste tinted with definite amounts of lampblack and compared with National Lead Company standards. On this scale of standards 100 represents the tinting strength of Dutch-process white lead using an established sample of excellent quality.

Oil Absorption

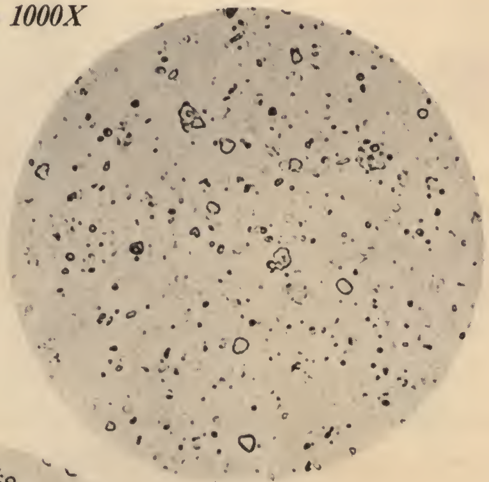
These figures have been determined in accordance with the A.S.T.M. Standard Method D-281-31 expressing the number of pounds of oil required to wet one hundred pounds of pigment.

PHOTOMICROGRAPHS OF NATIONAL LEAD COMPANY WHITE LEADS

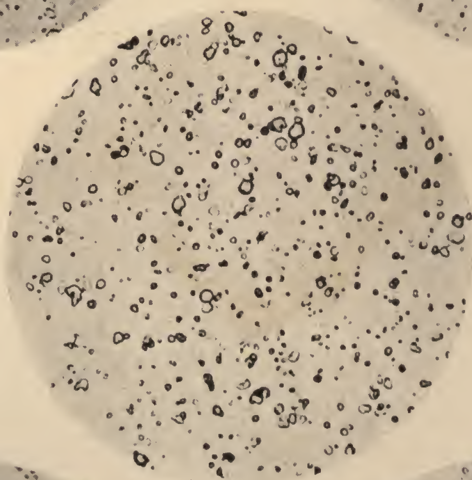
Magnification 1000X



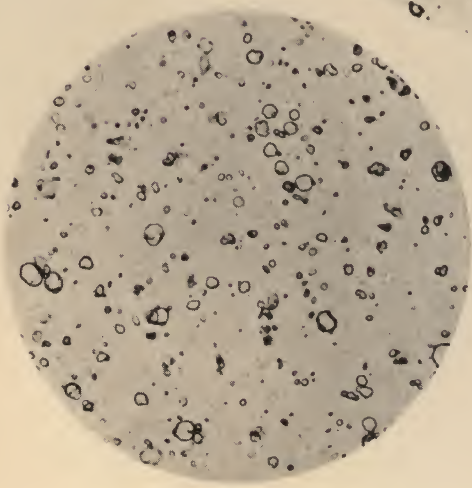
111



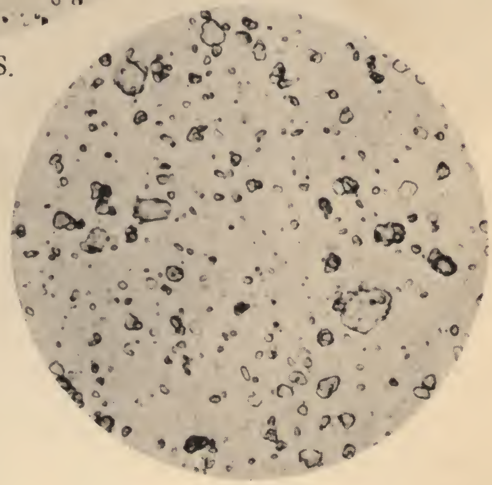
333



H.T.S.



CARTER



DUTCH

It should be pointed out here that the results of this test do not necessarily indicate the paint thickening power of a pigment. Generally a white lead with a high oil absorption will make a paint of heavier consistency than one with a low oil absorption. However, there are white leads of equal oil absorption and different paint thickening power and conversely there are white leads of different oil absorption and equal paint thickening power.

Paint Consistency

The consistency is determined by a standardized Gardner Mobilometer using a 120 gram plunger system and measuring the time of fall through the middle 10 centimeters of a 20 centimeter column of paint—temperature 70°F.±0.5°. The test paint mixture is made by grinding the white lead according to a standardized procedure in a linseed oil having an acid number of 2.5.

The results mentioned in Table A (page 4) apply to:

1st—A mixture of
- 71.3% by weight (25.4% by volume) White Lead
- 28.7% by weight (74.6% by volume) Linseed Oil

2nd—A mixture of
- 62.0% by weight (18.3% by volume) White Lead
- 38.0% by weight (81.7% by volume) Linseed Oil

∞ Indicates no movement of the plunger.

Thus these figures express the consistency of a mixture of definite composition.

Paint Thickening Power

The paint thickening power figures show the white lead content of a paint of definite consistency. The figures in the table represent the percentage, as well as the number of pounds of pigment required to make one gallon of a white lead and linseed oil mixture of a Gardner Mobilometer consistency of 20 seconds.

It must be understood that even slight changes in the test procedure for the determination of consistency as well as of paint thickening power will give variations. The figures given only illustrate the differences in consistency and paint thickening power which have been determined exactly in accordance with the methods outlined.

SELECTING THE PROPER TYPE OF WHITE LEAD

The variety of white leads available makes possible their inclusion in the following paint products: Outside House Paints, Exterior Primers, Special Exterior Finishes, Exterior Flat Paints, Interior Flat Paints.

In prepared paints white lead is generally combined with other pigments. These other pigments are used as a means for obtaining increased hiding or a greater degree of hardness. It must be remembered that too great a proportion of other pigments may cause a sacrifice of many desirable properties.

Some high hiding power pigments have a tendency to wash and others cause paint to chalk quite freely. The use of hardening pigments is dangerous since there is a limit to the degree of hardness which a paint film will tolerate and still have sufficient elasticity to give with the structure strains caused by temperature changes and by moisture. If the film is too hard any movement of the surface underneath will cause the paint to crack which destroys its protective value.

Caution should be exercised therefore in the use of pigments other than white lead as the advantages secured may be at the expense of essential properties, especially durability and adhesion.

The problem of formulation comprises the maintenance of as high a percentage of white lead as the desire for the use of other pigments will allow. Also to be considered is the correct choice of type of white lead to be used in each individual case. To do this it is necessary to know the general make-up of the paint that is to be produced and the special requirements to which it has to conform.

Outside House Paint

Frequently the consistency of the finished product in the container is an important factor in the choice of type of white lead that shall be used. A comparison between the different types of white lead in this characteristic will show

that the low to medium oil-absorption white leads have a tendency to make "longer" paints while No. 333 and No. 111 have a tendency to make so-called "short" or "piling" paints.

The hiding power desired in a paint may influence the choice of type of white lead to be used. In this case No. 333 and No. 111 will be generally more effective than a white lead which has lower complete hiding power per pound.

If pigments of high hiding power other than white lead are used they may reduce the pigment content of a paint to a point where its durability is seriously impaired. This danger may be avoided by the addition of a low to medium consistency white lead such as Dutch, Carter or H. T. S.

In cases where a heavy weight paint (of high specific gravity) is desired, low consistency white leads such as Dutch and Carter are the types best suited for this purpose.

Where cost is an important factor, a high paint thickening power white lead will be more in line with what is required. In such cases No. 333 and No. 111 will prove to be much more economical in use than white leads of lower paint thickening power.

Exterior Primers

This type of material demands durability and adhesion and a well pigmented film to form a good base for the subsequent coats. Here, the use of a lower consistency white lead is indicated. However, since hiding is of importance, generally H.T.S. white lead will prove to be most satisfactory for this purpose.

Special Exterior Finishes

Finishes of the type used on gas tanks, transformers, etc., generally require the presence of special vehicles. Frequently such vehicles tend to impair the brushing qualities of the product so that it is imperative that the pigment content be kept as low as is practically possible. For this reason the pigments used must have good hiding, be readily dispersed and maintain their good dispersion. Under these conditions where the presence of white lead is desired, No. 333 and No. 111, which possess the specified pigment requirements to a high degree, will be the most suitable types of white lead that can be used for the purpose.

Exterior Flat Paints

For painting building materials other than wood such as brick, stucco and concrete white lead has found wide application. Dutch and Carter white leads made into paints of high pigment concentration are most suitable for this purpose.

With the advent of composition shingles the paint industry has had to meet a new problem. For this type of surface a paint is needed which combines sealing with adhesion and elasticity. Sealing is mainly a function of the vehicle. In securing adhesion and elasticity, however, the pigment is of great importance. Experience has shown that white lead performs to satisfaction in paints for such surfaces.

Generally low oil absorption white leads such as Dutch and Carter are used. Other types may be employed with corresponding vehicle adjustments.

Interior Flat Paints

In many instances this paint has to be made at a price. On this basis low oil absorption white leads, although they impart many of the desirable qualities, usually raise the cost beyond practical consideration. However, the addition of small quantities of 111 white lead to flat paints is economically practical and has been found to impart better leveling, improved drying, easier brushing, better uniformity of appearance (lack of flashing) and improved washability. The quantities used vary from one-half to one pound of 111 white lead to a gallon of flat paint.

VOLUMETRIC PAINT FORMULATION

In the preceding description it has been pointed out that under certain conditions one definite type of white lead may be more suitable for a certain purpose than another. In order to secure the full benefit of each type, variations in pigment concentration are required. The application of these variations is simplified by the method of volumetric formulation now to be discussed.

In producing a paint the ultimate object is the construction of a paint film which most effectively serves the purpose for which it is intended. It must, of course, possess certain definite properties such as good appearance, protection and durability.

The performance of such a film is determined by the inherent characteristics of its ingredients and the volumes in which they are used. The character of a finished paint film is directly dependent upon the volume relationship of its constituent parts. The volumetric method of expressing the pigment content in a paint film has been widely adopted because it discloses graphically the structure of the film and does not change regardless of the bulking values of the pigments involved. On the other hand, if the formulation of a paint is expressed in weight units one cannot easily visualize the true relationship that exists between the different constituents in the paint film. A certain weight percentage of pigment in a paint may produce films of varying volumetric structure depending on the bulking values of the pigments used.

For instance paints made up on the basis of a weight formula of:

Pigment.. 66%
Vehicle (90% Oil—10% Volatile).................. 34%

will form films (See Figure 1) in which the volumetric pigment content is:

23.1% by volume when white lead is used
34.4% by volume when titanium-barium pigment is used
26.2% by volume when zinc oxide is used
39.2% by volume when titanium-magnesium pigment is used

Fig. 1

VOLUMETRIC VARIATION IN PIGMENT CONTENT

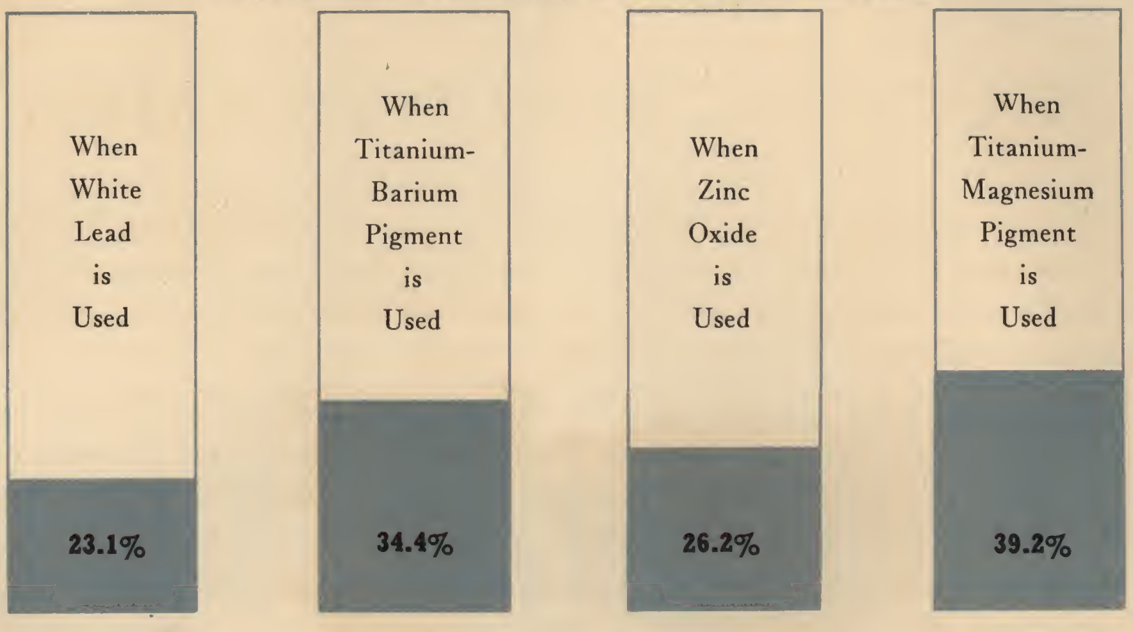
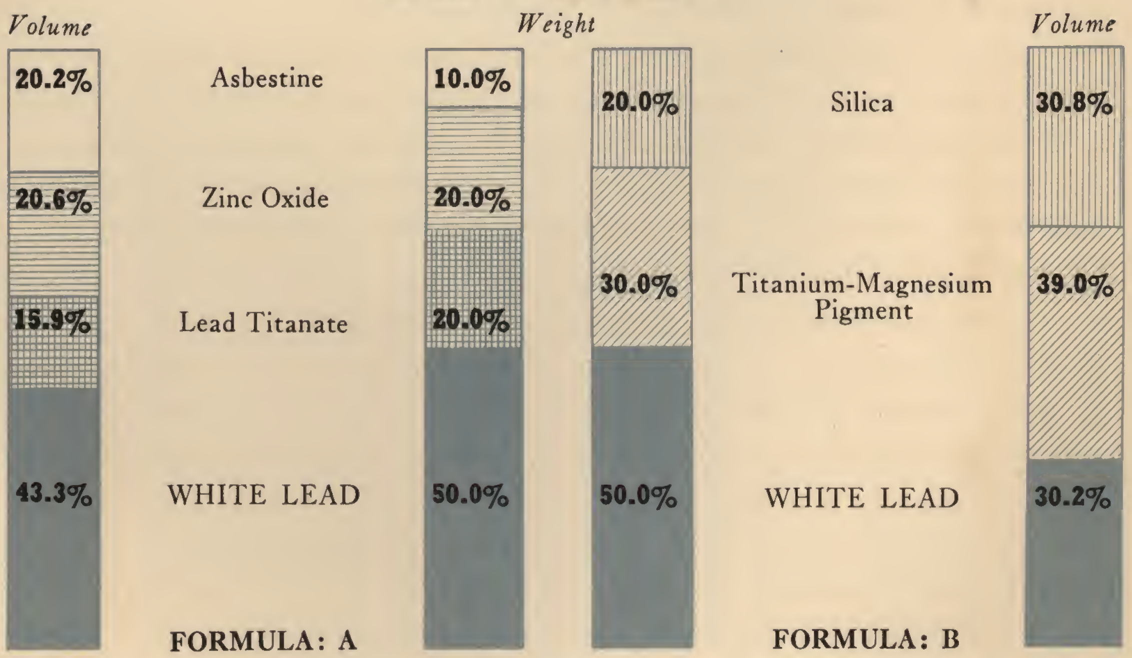


Fig. 2

WEIGHT VERSUS VOLUME



When the paint film contains more than one pigment it is just as necessary to consider the volumetric relationship of the individual pigments as it is to know the volumetric relationship between the total pigment and the vehicle. In the case of two mixed pigment paints, the percentage by weight of white lead contained may be the same for both but the percentage of white lead by volume will be different if the other pigments contained are not the same in each paint. Figure 2 shows such a difference.

The illustration shows that, in Formula A, 50% by weight of white lead equals 43.3% by volume of the pigment phase if it is used in combination with the stated percentages of lead titanate, zinc oxide and asbestine. The same 50% by weight, in Formula B, is only 30.3% by volume of the total pigment if the other pigments used are titanium-magnesium and silica in the given percentages.

It has been shown that weight ratios are not indicative of the ratios that exist by volume, demonstrating the importance of volumetric formulation as the only logical basis on which to design a well constructed paint.

The volume of pigment as related to the volume of non-volatile vehicle in the final paint film has a direct bearing on durability. This volume relationship is usually referred to as pigment-fixed vehicle ratio and will be represented hereafter as PV, the percentage of total pigment by volume in the total non-volatile portion of the paint.

As has been demonstrated, a volumetric formula should not only give the pigment-fixed vehicle ratio but also the volumetric percentages of the different pigments used. However, the picture cannot be complete without mention being made of the volatile, due to the fact that it influences the thickness of the paint film. This also should be represented as a volumetric percentage of the volatile in the total vehicle.

Volumetric formulation has additional advantages in that it is possible by this method to calculate a formula to a previously determined PV and to make it up in batches of any required size. In order to facilitate this procedure Table B may be used. This table gives the volumetric percentages of pigment, non-volatile and volatile required to obtain paints of a definite volumetric composition ranging in PV from 20 to 30 and in volatile from 10 to 20.

The use of this table is quite simple and the following example will make its operation clear.

EXAMPLE: 45 gallons of paint are required having a PV 29 and volatile 12.

The PV required is selected from the top line of figures and the volatile from the extreme left or right hand columns. In this instance the volumetric percentages are chosen which may be found at the intersection formed by the vertical column headed by 29 for PV and the horizontal column designated 12 for volatile. The following figures are then found:

Pigment	26.4% by volume
Non-Volatile	64.7% by volume
Volatile	8.9% by volume

These are the percentages of the constituents required to make a paint meeting the specifications given above. Since Table B is computed on a basis of 100 units, to make 45 gallons these figures have to be multiplied by .45 resulting in:

11.880	Gallons	Pigment
29.115	Gallons	Non-Volatile
4.005	Gallons	Volatile

It is obvious that a volume formula cannot be used in factory practice. Pigments cannot be measured by volume and for vehicles weighing is more accurate. However, it is a very simple matter to transpose volume into weight. This can be done using Table D opposite page 24 which gives the bulking values of the various pigments expressed in number of pounds per solid gallon. It is then a matter of multiplying by the number of gallons required.

If we continue with the example just previously given and prepare a white-lead paint, the conversion of volumetric formula into factory weight formula will result in the following figures:

11.880 Gallons White Lead	at 56 lbs. =	665	Pounds
29.115 Gallons Linseed Oil	at 7¾ lbs. =	226	Pounds
3.005 Gallons Thinner	at 6½ lbs. =	19½	Pounds
1.000 Gallons Liquid Drier*	at 7½ lbs. =	7½	Pounds
45.000 Gallons		918	Pounds

At times it may be necessary to apply changes to an existing formula. The exact way to do this is to use the original volumetric formula as a basis. Applying

*The low non-volatile content in liquid drier cannot have much effect on the ultimate volumetric structure of the paint film, so that for the sake of simplicity the entire quantity of drier is calculated as volatile.

TABLE B

PIGMENT—FIXED VEHICLE RATIO

	20	21	22	23	24	25	26	27	28	29	30	
10	18.4 73.4 8.2	19.3 72.6 8.1	20.2 71.8 8.0	21.1 71.0 7.9	22.1 70.1 7.8	23.1 69.2 7.7	24.0 68.4 7.6	25.0 67.5 7.5	25.9 66.7 7.4	26.9 65.8 7.3	27.8 65.0 7.2	**10**
11	18.2 72.8 9.0	19.1 72.0 8.9	20.0 71.2 8.8	21.0 70.3 8.7	21.9 69.5 8.6	22.9 68.6 8.5	23.8 67.8 8.4	24.8 67.0 8.2	25.7 66.1 8.2	26.6 65.3 8.1	27.6 64.4 8.0	**11**
12	18.0 72.1 9.9	18.9 71.4 9.7	19.9 70.4 9.7	20.8 69.7 9.5	21.7 68.9 9.4	22.7 68.1 9.2	23.6 67.2 9.2	24.5 66.4 9.1	25.5 65.6 8.9	26.4 64.7 8.9	27.4 63.9 8.7	**12**
13	17.9 71.4 10.7	18.8 70.7 10.5	19.7 69.9 10.4	20.6 69.1 10.3	21.5 68.3 10.2	22.5 67.4 10.1	23.4 66.6 10.0	24.4 65.8 9.8	25.3 65.0 9.7	26.2 64.2 9.6	27.2 63.3 9.5	**13**
14	17.7 70.8 11.5	18.6 70.0 11.4	19.5 69.2 11.3	20.4 68.4 11.2	21.3 67.6 11.1	22.3 66.8 10.9	23.2 66.1 10.7	24.1 65.3 10.6	25.1 64.4 10.5	26.0 63.6 10.4	26.9 62.9 10.2	**14**
15	17.5 70.1 12.4	18.4 69.4 12.2	19.3 68.6 12.1	20.2 67.8 12.0	21.1 67.0 11.9	22.1 66.2 11.7	23.0 65.4 11.6	23.9 64.7 11.4	24.8 63.9 11.3	25.8 63.1 11.1	26.7 62.3 11.0	**15**
16	17.4 69.4 13.2	18.2 68.7 13.1	19.1 67.9 13.0	20.0 67.3 12.8	21.0 66.4 12.6	21.9 65.6 12.5	22.8 64.8 12.4	23.7 64.1 12.2	24.6 63.3 12.1	25.5 62.5 12.0	26.5 61.8 11.7	**16**
17	17.2 68.7 14.1	18.1 68.0 13.9	19.0 67.2 13.8	19.9 66.5 13.6	20.8 65.7 13.5	21.7 65.0 13.3	22.6 64.2 13.2	23.5 63.5 13.0	24.4 62.8 12.8	25.3 62.0 12.7	26.2 61.3 12.5	**17**
18	17.0 68.1 14.9	17.9 67.4 14.7	18.8 66.6 14.6	19.7 65.9 14.4	20.6 65.1 14.3	21.5 64.4 14.1	22.4 63.6 14.0	23.3 62.9 13.8	24.2 62.2 13.6	25.1 61.4 13.5	26.0 60.7 13.3	**18**
19	16.8 67.3 15.9	17.7 66.7 15.6	18.6 65.9 15.5	19.5 65.2 15.3	20.4 64.5 15.1	21.2 63.8 15.0	22.1 63.1 14.8	23.1 62.3 14.6	23.9 61.6 14.5	24.9 60.8 14.3	25.8 60.1 14.1	**19**
20	16.7 66.7 16.6	17.5 66.0 16.5	18.4 65.3 16.3	19.3 64.6 16.1	20.2 63.8 16.0	21.1 63.1 15.8	22.0 62.4 15.6	22.8 61.7 15.5	23.7 61.0 15.3	24.6 60.3 15.1	25.5 59.6 14.9	**20**
	20	21	22	23	24	25	26	27	28	29	30	

weight changes without considering the bulking values of the different pigments may produce the most unexpected results.

For instance, for reasons of cost it may be decided to alter a paint formula by the addition of extender. Assuming that the pigment phase of the factory weight formula shows the figures below in Formula A and that the intention is to add 20% asbestine (on a weight basis) by proportionately reducing the opaque pigments. Then

Formula A		*Formula B*
600 lbs. White Lead		480 lbs. White Lead
250 lbs. Titanium-Barium Pigment	*becomes*	200 lbs. Titanium-Barium Pigment
150 lbs. Zinc Oxide		120 lbs. Zinc Oxide
		200 lbs. Asbestine

The effect on the volumetric structures of Formulas A and B as compared to their weight equivalents are shown in Figure 3.

Fig. 3

WEIGHT FORMULA CHANGES COMPARED WITH THE RESULTING VOLUMETRIC STRUCTURE CHANGES

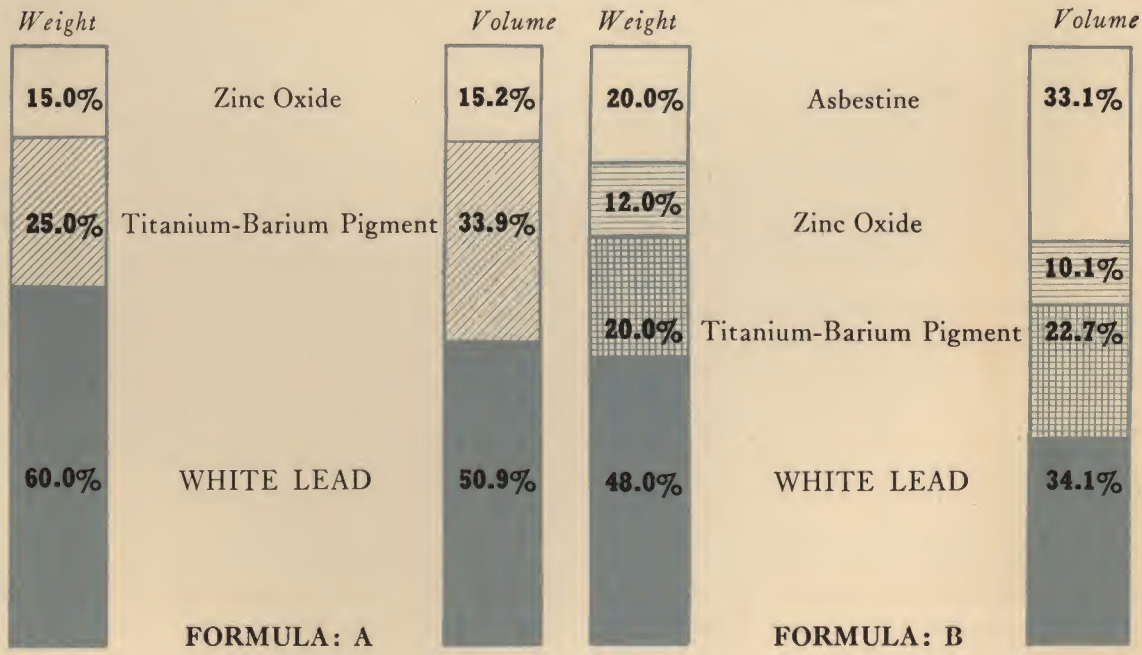


TABLE C
WEIGHT-VOLUME EQUIVALENTS

	White Lead Carbonate	*White Lead Sulphate*	*Titanox A*	*Ti-B30, HS-Litho-Ti-Litho*	*Titanox C Titanox M*	*Titanox L*	*Zinc Oxide*	*Lithopone*	*Zinc Sulfide*	*Asbestine*	*Silica Whiting*	*Barytes*	*Diat. Earth*
White Lead, Carbonate	1.00	1.06	1.75	1.60	2.16	.90	1.19	1.56	1.70	2.34	2.55	1.52	2.80
White Lead, Sulphate	.95	1.00	1.66	1.52	2.04	.86	1.13	1.48	1.61	2.21	2.41	1.43	2.65
Titanox A	.57	.61	1.00	.92	1.23	.52	.68	.89	.97	1.34	1.46	.87	1.60
Titanox B-30	.63	.66	1.10	1.00	1.35	.58	.75	.97	1.06	1.46	1.59	.95	1.75
Titanox C	.47	.49	.81	.74	1.00	.42	.56	.72	.79	1.09	1.18	.70	1.30
Titanox M	.47	.49	.81	.74	1.00	.42	.56	.72	.79	1.09	1.18	.70	1.30
Titanox L	1.09	1.15	1.91	1.74	2.35	1.00	1.30	1.70	1.85	2.55	2.78	1.65	3.05
Zinc Oxide	.84	.89	1.47	1.34	1.81	.76	1.00	1.31	1.43	1.96	2.14	1.27	2.35
Lithopone	.64	.68	1.12	1.03	1.38	.59	.77	1.00	1.09	1.50	1.64	.98	1.80
Lithopone, High Strength	.63	.66	1.10	1.00	1.35	.58	.75	.97	1.06	1.46	1.59	.95	1.75
Lithopone, Titanated	.63	.66	1.10	1.00	1.35	.58	.75	.97	1.06	1.46	1.59	.95	1.75
Zinc Sulphide	.59	.62	1.03	.96	1.27	.54	.70	.92	1.00	1.38	1.50	.89	1.65
Asbestine	.43	.45	.75	.69	.92	.39	.51	.67	.73	1.00	1.09	.65	1.20
Barytes	.66	.70	1.16	1.06	1.42	.60	.79	1.03	1.12	1.55	1.68	1.00	1.85
Diatomaceous Earth	.36	.48	.63	.57	.77	.33	.43	.56	.61	.84	.91	.54	1.00
Silica	.40	.42	.69	.63	.85	.34	.47	.61	.67	.92	1.00	.60	1.10
Whiting	.40	.42	.69	.63	.85	.34	.47	.61	.67	.92	1.00	.60	1.10

From top listing select name of pigment which is to be replaced. Choose replacement pigment from left hand column. Follow horizontally to the right until vertical column headed by name of pigment first selected is intersected. Weight figure found at the intersection represents a volume of replacement pigment equal to that of one pound of pigment to be replaced.

In comparing Formulas A and B it is interesting to note that, while a white lead weight reduction has been effected as from 60 to 48 which is one-fifth, the actual volume reduction is from 50.9 to 34.1 which is one-third. It is obvious that so radical a decrease in volume must have a considerable influence on the quality of the paint, in fact, entirely out of proportion as compared to the cost.

At the same time it is shown that the addition of extender has not resulted in a reduction in the opaque pigments of just 20% as contemplated, but in a true decrease of 33.1%.

Finally the method of weight replacement not only affects the volume proportions of the pigment phase of a paint but disturbs the PV and the batch yield as well.

From the preceding discussion the great importance of considering volume relationships when weight reductions are made should be obvious.

It is appreciated that many formulas exist that have been developed on a weight basis. In cases where it might seem desirable to make adjustments in the factory weight formula a method has been developed which will facilitate such a procedure. This involves the use of Table C which gives weight-volume equivalents for the various white pigments.

The advantage of this method of replacement is that the batch yields remain unchanged. Furthermore, the PV is not disturbed and the opaque pigment content is reduced exactly by the volume as well as by the weight desired.

As an example showing the use of Table D, Formula A may again be used as a starting point.

Formula A

600 Pounds White Lead
250 Pounds Titanium-Barium Pigment
150 Pounds Zinc Oxide

The assumption is that 20% of the weight of the opaque pigments is to be replaced with an equivalent volume of asbestine. This replacement is to be made in proportion to the weights as they existed in the original formulation. Consequently a volume of asbestine is to be introduced which is equivalent to the combined volumes represented by 20% of the weight of each pigment in Formula A. For this purpose the volume values have to be found for:

120 Pounds White Lead
50 Pounds Titanium-Barium Pigment
30 Pounds Zinc Oxide

Through the use of Table D the following results are obtained:

White Lead	120 lbs. × .43 equals	51.6 lbs. Asbestine
Titanium-Barium Pigment	50 lbs. × .69 equals	34.5 lbs. Asbestine
Zinc Oxide	30 lbs. × .51 equals	15.3 lbs. Asbestine
	200 lbs. replaced by	101.4 lbs. Asbestine

The application of this change results in:

Formula C:

480 Pounds White Lead
200 Pounds Titanium-Barium Pigment
120 Pounds Zinc Oxide
101 Pounds Asbestine

FORMULATING WITH WHITE LEAD

Thus far, volumetric formulation and the various types of white lead available have been discussed individually. It is now necessary that these two factors be correlated and applied to the making of paint.

In formulating any kind of paint the first consideration is the construction of the paint film. The inherent characteristics of a paint originate in the raw materials, and the extent to which they function in the paint film is dependent on the proportions used. The PV is particularly important because it is responsible for the consistency, hiding and durability of the paint.

It is obvious that variations in required PV can occur, due to the availability of raw materials with varying properties. With the different types of white lead the PV requirements to obtain the necessary consistency and hiding may be derived from the figures found in Table A on page 5.

In order to secure information regarding the optimum durability obtainable, dependent on the PV, many exposure tests have been conducted over a period of a great number of years at the National Lead Company Experimental Station at Sayville, L. I. These tests are run under various exposures on all commonly used construction materials. Every care is taken to reproduce as far as possible actual surface conditions. For example, the tests on wood siding include applications of the same paint on yellow pine, cedar, cypress and white pine. This type of test has been carried on regularly each year. In the following, the PV test range for the various white leads is shown and the effective PV for each type is discussed.

PAINTS TESTED

PV	37.3	33.5	30.3	28.0	27.7	26.0	25.5	25.0	23.6	23.0	21.0
Volatile & Drier	11.0	9.4	8.2	12.5	7.3	12.8	6.6	12.4	6.0	12.6	12.6

Dutch White Lead

PV 27.7 generally shows up somewhat better than the lower pigment concentration. The higher PV paints contain too little oil for southern exposure, but PV 30.3 shows up well on the north side.

Carter and H. T. S. White Leads

Results of many series of tests have always compared substantially the same. However, it is generally indicated that for H.T.S. the PV requirement is somewhat lower.

333 and 111 White Leads

There are definite indications of better gloss retention and delayed chalking, especially noticeable in grays. A curve of the results seems to give a definite break. For No. 333 the best results are obtained at PV's lower than 26.0 and for No. 111 at PV's lower than 24.0.

The results of these tests indicate that for use in the manufacture of prepared paints the following PV's are most suitable:

Dutch	Carter	H.T.S.	333	111
30	30	29	25	23

These figures are based on the use of a vehicle consisting of:

85% by volume Non-Volatile (viscosity approx. ½ poise)
15% by volume Volatile and Drier

This stipulation is necessary in order to satisfy consistency requirements.

In applying these figures to the manufacture of paints, it must also be recognized that the exact PV required for a paint containing other pigments besides white lead has never been definitely fixed. At least, opinions on this point and actual practice differ so widely that no basic figure can as yet be accepted. Although a required PV of from 28 to 30 is often accepted for outside house paint, products of this type at present manufactured and for sale in this country show variations in PV from as low as 21 to as high as 31.

In comparing the merits of the different types of white lead in mixed pigment paints, it should be assumed that each prepared paint under consideration has been formulated to a specific PV which most fully meets the practical requirements of that paint. In such a case the white lead PV figures suggested should be considered from their comparative values. For instance, to show up 333 white lead to its best advantage in a mixed pigment paint it should be of a lower PV than a similar paint in which Carter white lead is used. The following example where No. 333 is to be substituted for Dutch white lead will demonstrate the method of making such a change.

A paint manufacturer is making an outside house paint with a PV of 29 and in which the pigment phase consists of:

60% by volume (67.3% by weight) Dutch White Lead
20% by volume (14.2% by weight) Titanium-Barium Pigment
20% by volume (18.5% by weight) Zinc Oxide

It is assumed that he wishes to replace the Dutch white lead with No. 333. The difference in required PV between the two white leads, taking those recommended on page 21, is five points. Since the pigment phase of the paint contains 60% by volume of white lead, a replacement with No. 333 requires a PV reduction of 60% of five points or three points. Thus with the use of the latter type of pigment, the above mentioned paint should be formulated to a PV of 26.

It must be borne in mind that it would seem unwise, where theoretically a reduction in PV is indicated as a result of such a replacement, to effect such a reduction if it were to bring the PV of the paint down to a figure lower than the PV requirement figure indicates for the type of white lead used.

For instance, assume that a manufacturer is producing a paint in which the pigment phase consists of white lead and zinc oxide. The PV of this paint is 24 and he wishes to replace the type of white lead used at present with No. 333. Because the basis (PV-24) is lower than the 25 set for No. 333 White Lead, the replacement should be made pound for pound and the base PV thus left unchanged.

Some examples will be given of adjustments in formulas where respectively hiding, weight or price are considered of prime importance. In each instance two comparable formulas are shown in which the white leads used differ and in which the formulations have been calculated according to the method previously explained. The examples are intended for demonstration purposes and do not constitute definite recommendations.

IMPORTANT REQUIREMENT—HIDING

If high hiding is the primary consideration, the following comparable formulas demonstrate that the use of a high consistency white-lead is advantageous even though the pigment content of the paint must be reduced.

Existing General Specification:

Pigment	25.5 Gallons
Non-Volatile	62.5 Gallons
Volatile	12.0 Gallons

Pigment Phase:

White Lead	47% by volume	(58% by weight)
Titanium Oxide	10% by volume	(7% by weight)
Zinc Oxide	24% by volume	(25% by weight)
Asbestine	19% by volume	(10% by weight)

PV: 29.0 Volatile and Drier: 16.0%

.47 × 25.5 = 11.985 gals. × 56	=	671 lbs.	Carter White Lead	× 14 =	9,394 sq. ft.
.10 × 25.5 = 2.550 gals. × 32	=	82 lbs.	Titanium Dioxide	× 115 =	9,430 sq. ft.
.24 × 25.5 = 6.120 gals. × 47	=	288 lbs.	Zinc Oxide	× 23 =	6,624 sq. ft.
.19 × 25.5 = 4.845 gals. × 24	=	116 lbs.	Asbestine	=	
25.5 gals.		1157 lbs.	Pigment		25,448 sq. ft.
62.5 gals. × 7¾	=	484 lbs.	Oil		
12.0 gals. × 6.4	=	77 lbs.	Volatile and Drier		
100.0 gals.		1718 lbs.			

HIDING PER GALLON: 254 SQUARE FEET

HIDING INCREASED

Revised General Specification:

Pigment	23.7 Gallons
Non-Volatile	64.1 Gallons
Volatile	12.2 Gallons

Pigment Phase: As Above PV: 27.0 Volatile and Drier: 16.0%

.47 × 23.7 = 11.139 gals. × 57	=	635 lbs.	333 White Lead	× 21 =	13,335 sq. ft.
.10 × 23.7 = 2.370 gals. × 32	=	76 lbs.	Titanium Dioxide	× 115 =	8,740 sq. ft.
.24 × 23.7 = 5.688 gals. × 47	=	267 lbs.	Zinc Oxide	× 23 =	6,141 sq. ft.
.19 × 23.7 = 4.503 gals. × 24	=	108 lbs.	Asbestine		
23.7 gals.		1086 lbs.	Pigment		28,216 sq. ft.
64.1 gals. × 7¾	=	497 lbs.	Oil		
12.2 gals. × 6.4	=	78 lbs.	Volatile and Drier		
100.0 gals.		1661 lbs.			

HIDING PER GALLON: 282 SQUARE FEET

IMPORTANT REQUIREMENT—WEIGHT

The following example shows that where high specific gravity paints are desired the low oil absorption types of white lead are more effective.

Existing General Specification:

Pigment	23.0 Gallons
Non-Volatile	65.4 Gallons
Volatile	11.6 Gallons

Pigment Phase:

White Lead	60% by volume (67% by weight)
Titanium-Barium	20% by volume (14% by weight)
Zinc Oxide	20% by volume (19% by weight)

PV: 26.0 Volatile and Drier: 15.0%

.60×23.0=13.8 gals.×57	= 787 lbs.	111 White Lead
.20×23.0= 4.6 gals.×35	= 161 lbs.	Titanium-Barium
.20×23.0= 4.6 gals.×47	= 216 lbs.	Zinc Oxide
23.0 gals.	1164 lbs.	Pigment
65.4 gals.× 7¾=	507 lbs.	Oil
11.6 gals.× 6.4=	74 lbs.	Volatile and Drier
100.0 gals.	1745 lbs.	

WEIGHT PER GALLON: 17.45 POUNDS

WEIGHT INCREASED

Revised General Specification:

Pigment	26.7 Gallons
Non-Volatile	62.3 Gallons
Volatile	11.0 Gallons

Pigment Phase: As Above PV: 30.0 Volatile and Drier: 15.0%

.60×26.7=16.02 gals.×56	= 897 lbs.	Dutch White Lead
.20×26.7= 5.34 gals.×35	= 187 lbs.	Titanium-Barium
.20×26.7= 5.34 gals.×47	= 251 lbs.	Zinc Oxide
26.7 gals.	1335 lbs.	Pigment
62.3 gals.× 7¾=	484 lbs.	Oil
11.0 gals.× 6.4=	71 lbs.	Volatile and Drier
100.0 gals.	1890 lbs.	

WEIGHT PER GALLON: 18.9 POUNDS

IMPORTANT REQUIREMENT—COST

Economies can be effected by use of the proper types of white lead as demonstrated by the following:

Existing General Specification:

Pigment...............23.7 Gallons
Non-Volatile...........61.0 Gallons
Volatile................15.3 Gallons

Pigment Phase:

White Lead...50% by volume (60% by weight)
Zinc Oxide....30% by volume (30% by weight)
Asbestine......20% by volume (10% by weight)

PV: 28.0 Volatile and Drier: 20.0%

.50 × 23.7 = 11.85 gals. × 56	= 664 lbs.	H. T. S. White Lead	at	7¼c	$ 48.14
.30 × 23.7 = 7.11 gals. × 47	= 334 lbs.	Zinc Oxide	at	6½c	$ 21.71
.20 × 23.7 = 4.74 gals. × 24	= 114 lbs.	Asbestine	at	1c	$ 1.14
23.7 gals.	1112 lbs.	Pigment			$ 70.99
61.0 gals. × 7¾ =	473 lbs.	Oil	at	10c	$ 47.30
15.3 gals. × 6.4 =	98 lbs.	Volatile and Drier	at	2c	$ 1.96
100.0 gals.	1683 lbs.				$120.25

COST PER 100 GALLONS: $120.25

COST DECREASED

Revised General Specification:

Pigment...............22.0 Gallons
Non-Volatile...........62.4 Gallons
Volatile................15.6 Gallons

Pigment Phase:

As Above
PV:26.0
Volatile and Drier: 20%

.50 × 22.0 = 11.00 gals. × 57	= 627 lbs.	333 White Lead	at	7¼c	$ 45.46
.30 × 22.0 = 6.60 gals. × 47	= 310 lbs.	Zinc Oxide	at	6½c	$ 20.15
.20 × 22.0 = 4.40 gals. × 24	= 106 lbs.	Asbestine	at	1c	$ 1.06
22.0 gals.	1043 lbs.	Pigment			$ 66.67
62.4 gals. × 7¾ =	484 lbs.	Oil	at	10c	$ 48.40
15.6 gals. × 6.4 =	100 lbs.	Volatile and Drier	at	2c	$ 2.00
100.0 gals.	1627 lbs.				$117.07

COST PER 100 GALLONS: $117.07

This comparison demonstrates the economy of high paint thickening quality white leads and also shows the way towards improvement of the paint without additional cost by increasing the white lead content. For example, compare the original cost formula with the following:

.57 × 22.0 = 12.54 gals. × 57	= 715 lbs.	333 White Lead	at	7¼c	$ 51.84
.25 × 22.0 = 5.50 gals. × 47	= 259 lbs.	Zinc Oxide	at	6½c	$ 16.83
.18 × 22.0 = 3.96 gals. × 24	= 95 lbs.	Asbestine	at	1c	$ .95
22.0 gals.	1069 lbs.	Pigment			$ 69.62
62.4 gals. × 7¾ =	484 lbs.	Oil	at	10c	$ 48.40
15.6 gals. × 6.4 =	100 lbs.	Volatile and Drier	at	2c	$ 2.00
100.0 gals.	1653 lbs.				$120.02

TABLE D

PROPERTIES OF WHITE PIGMENTS

		BULKING		OIL ABS.		HIDING		PT. THICK. P.	
	SPEC. GRAV.	LBS. PER GAL.	GAL. PER LB.	% PER LB.	% PER GAL.	SQ.FT. PER LB.	SQ.FT. PER GAL.	LBS. PER GAL.	% BY VOL.
Dutch White Lead	6.7	56	.0179	8	58	13	728	17	30
Carter White Lead	6.7	56	.0179	9	65	15	784	16	29
H. T. S. White Lead	6.7	56	.0179	10	72	17	952	12	22
#333 White Lead	6.8	57	.0175	14	104	21	1197	11	19
#111 White Lead	6.8	57	.0175	15	111	25	1482	10	18
Dutch Boy Basic Lead Sulphate	6.4	53	.0189	14	96	16	848	9	17
Fumed Basic Lead Sulphate	6.3	52	.0192	10	67	13	676	14	27
Titanox A	3.9	32	.0312	23	95	115	3680	4	13
Titanox B-30	4.2	35	.0286	17	77	46	1610	9	26
Titanox C	3.1	26	.0385	22	74	48	1248	6	23
Titanox M	3.1	26	.0385	20	67	47	1222	5	20
Titanox L	7.3	61	.0164	10	78	57	3477	12	21
Zinc oxide	5.6	47	.0212	17	104	23	1081	6	13
Leaded Zinc Oxide 5%	5.6	47	.0212	17	104	22	1034	6	13
Leaded Zinc Oxide 35%	5.9	49	.0204	14	89	17	833	9	18
Leaded Zinc Oxide 50%	6.0	50	.0200	13	84	16	800	10	20
Lithopone	4.3	36	.0278	16	74	28	1008	8	22
Lithopone, High Strength	4.2	35	.0286	17	77	43	1505	7	20
Lithopone, Titanated	4.2	35	.0286	19	86	43	1505	6	17
Zinc Sulphide	4.0	33	.0303	20	85	58	1914	8	24
Asbestine	2.9	24	.0417	20	62				
Barytes	4.4	37	.0270	8	38				
Blanc Fixe	4.3	36	.0278	12	56				
Diatomaceous Earth	2.4	20	.0500	97	250				
Silica	2.7	22	.0454	23	66				
Whiting	2.7	22	.0454	20	57				